

Attorney Docket No. 0756-7732

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: ) Confirmation No.: 9757  
Harue NAKASHIMA et al. ) Examiner: Andrew K. Bohaty  
Serial No. 10/585,326 ) Group Art Unit: 1786  
Filed: July 6, 2006 )  
For: CARBAZOLE DERIVATIVE, AND )  
LIGHT-EMITTING ELEMENT AND )  
LIGHT-EMITTING DEVICE USING )  
THE CARBAZOLE DERIVATIVE )

**DECLARATION OF SATOSHI SEO UNDER 37 C.F.R. § 1.132**

I, Satoshi Seo, hereby declare the following:

1. I am Satoshi Seo of Semiconductor Energy Laboratory, Co., Ltd. 398, Hase, Atsugi, Kanagawa 243-0036, Japan.
2. I graduated from the master course of Institute of Industrial Science, the University of Tokyo in the year 2000, and have since been employed by Semiconductor Energy Laboratory Co., Ltd. My research at Semiconductor Energy Laboratory Co., Ltd. has been focused on the development of new materials for organic light-emitting devices, new device structures of the highly efficient organic light-emitting devices, new methodology for fabrication of the organic light-emitting devices (OLEDs), and new structures of an active- and passive matrix type organic light-emitting devices. I am currently an organizer (vice-director) of a group in which research and development are conducted for the design and synthesis of organic materials and fabrication of display devices such as the organic light-emitting devices and liquid crystal display devices.
3. I have the following relevant qualifications and experience:

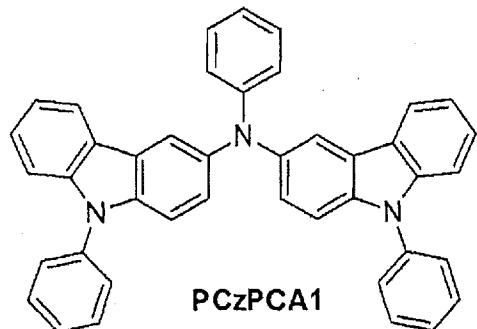
i) I am one of the inventors of the above-captioned application, Serial No. 10/585,326.

ii) I have approximately 360 patent application publications in Japan, approximately 400 patent application publications in the United States, and approximately 700 patent application publications in countries other than the United States and Japan. I have approximately 90 issued patents in Japan, approximately 200 issued patents in the United States, and approximately 200 issued patents in countries other than the United States and Japan. I have also published 15 papers in the field of organic light-emitting devices and displays utilizing these devices. These patent application publications, patents, and papers relate to my research in the field of organic light-emitting devices.

4. I have reviewed the Office Action dated January 21, 2011, for the present application (Serial No. 10/585,326), as well as U.S. Publication No. 2004/0185300 to Hatwar, Liu (Synthetic Metals 2004, 146, 85-89), and Thomas (Journal of the American Chemical Society, 2001, Volume 123, Pages 9404-9411).

5. I have performed experiments to compare the initial performance of various light-emitting devices with the following compounds as a material for use in the hole injection layer:

i) 3-[N-(9-phenylcarbazole-3-yl)-N-phenylamino]-9-phenylcarbazole ("PCzPCA1," a carbazole derivative corresponding with general formula (1) of claim 29 of the present application), shown below:



ii) N,N-Di(9-ethylcarbaz-3-yl)-3-methylaniline (compound DECMA of D. Liu et al., Synthetic Metals 2004, 146, 85-89), shown below:

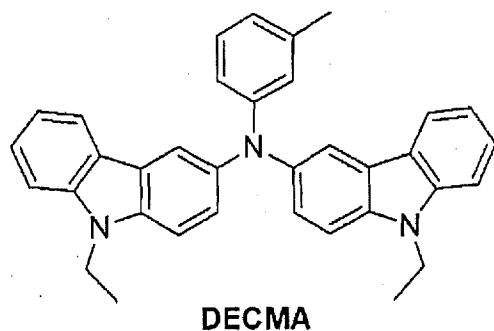
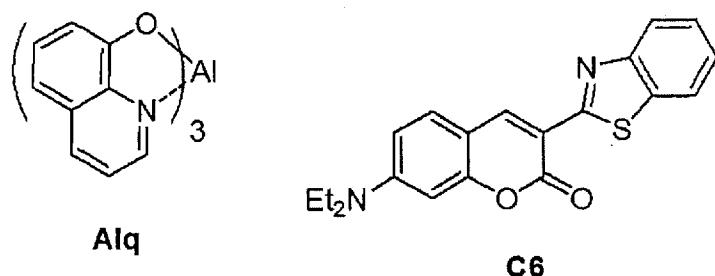
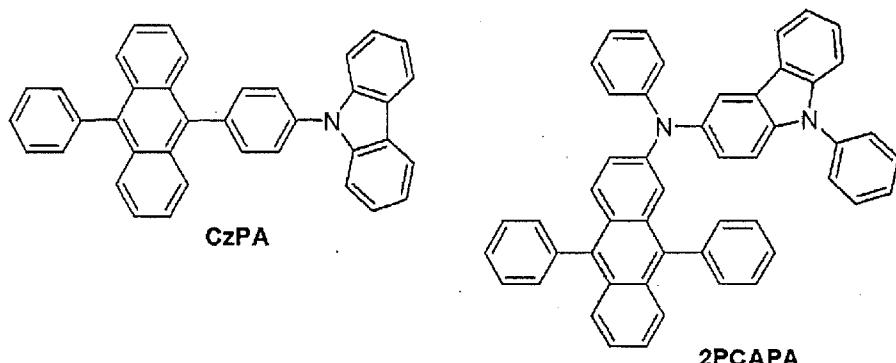
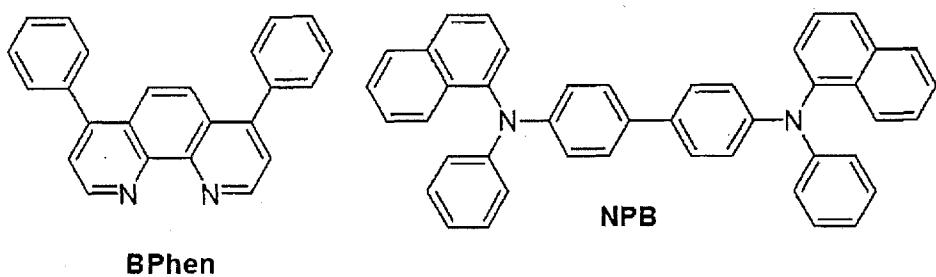


Exhibit 1 shows emission characteristics of light-emitting devices 1 and 3 with PCzPCA1 and DECMA as hole injection layers (HIL), respectively and CzPA:2PCAPA (1:0.05) as an emission layer (EmL). Exhibit 2 shows emission characteristics of light-emitting devices 2 and 4 having PCzPCA1 and DECMA as hole injection layers, respectively and Alq:C6 (1:0.01) as an emission layer. The parenthetical values refer to the volume ratio of the two compounds in the emission layer. CzPA functions as a host material for a variety of emitters. 2PCAPA and C6 were used as a green emissive dopant. The structures of CzPA, 2PCAPA, Alq and C6, respectively, are shown below:



Additionally, each of the light-emitting devices included the Alq compound in a first electron transmitting layer (ETL1) and the compound BPhen in a second electron transmitting layer (ETL2), as well as compound NPB as a hole transporting layer (HTL). NPB and Alq are the most frequently used hole and electron transporting materials, respectively. BPhen is a well known electron transporting material. The structure of the BPhen and NPB compounds are shown below:



Accordingly, devices 1 to 4 were prepared having the following structures interposed between an anode formed of NITO (which comprises ITO and silicon oxide) and an anode formed of aluminium.

No.	HIL (20 nm)	HTL (20 nm)	EmL (40 nm)	ETL1 (10 nm)	ETL2 (20 nm)	EIL (1 nm)
1	PCzPCA1	NPB	CzPA:2PCAPA (1:0.05)	Alq	BPhen	LiF
2	PCzPCA1		Alq:C6 (1:0.01)			
3	DECMA		CzPA:2PCAPA (1:0.05)			
4	DECMA		Alq:C6 (1:0.01)			

6. Exhibit 1 shows a comparison of initial performance of light-emitting devices 1 and 3, including plots of current vs. voltage and luminance vs. voltage. Comparison of the devices 1 and 3 permitted me to evaluate differences in performance between the compounds DECMA and PCzPCA1 as a material for an OLED. Specifically, such comparison provides a good measure of the hole injection ability of these compounds. The hole injection ability can be estimated by the comparison of the driving voltage of the device because the structures of the devices are the same other than the hole injection layer.

As seen from the respective current-voltage curves (left graph), comparison of devices 1 with 3 indicates that electrical current more readily follows in device 1 than in device 3. For example, the driving voltage of device 1 at a current of 20 mA was 7.6 V, whereas that of device 3 at the same current was 8.4 V. These results demonstrate that the driving voltage of the device 1 is smaller than that of device 3. Since the sole structural difference between devices 1 and 3 is the composition of the hole injection layer, it can be concluded that the hole injection ability of the invented compound is superior to the compound taught by Liu.

Furthermore, the higher hole injection ability of the claimed compound contributes to the reduced voltage requirement to obtain the same luminance as shown in the voltage-dependence of the luminance of the device (right graph). For example, a high value of luminance (10,000 cd/m<sup>2</sup>) can be

obtained at 6.4 V in the case of device 1, while a higher voltage (6.9 V) is required in the case of the device 3.

7. Exhibit 2 shows a similar comparison of initial performance of light-emitting devices 2 and 4, again including plots of current vs. voltage and luminance vs. voltage. Comparison of the devices 2 and 4 confirmed the above-referenced differences in performance between the compounds DECMA and PCzPCA1 as a material for an OLED. As seen from the current-voltage curves (left graph) electrical current flows more readily in device 2 than in device 4. Driving voltage of device 2 at a current of 20 mA was 7.8 V, whereas that of device 4 at the same current was 8.6 V. These results again indicate that the driving voltage of the device 2 is smaller than that of device 4. In other words, device 2 requires less voltage than device 4 to obtain the same current. Since the sole structural difference between devices 2 and 4 is again the composition of the hole injection layer, it can be concluded that the hole injection ability of the invented compound is superior to the compound taught by Liu.

Also, as with devices 1 and 3, the higher hole injection ability of the claimed compound contributes to a superior voltage-luminance characteristic, as shown in the voltage-dependence of the luminance of the device (right graph). For example, a luminance of 10,000 cd/m<sup>2</sup> can be obtained at 6.8 V in the case of device 2, while a higher voltage, 7.4 V, is required by device 4.

8. All of these results tend to show that the compound falling in the scope of the present claims (e.g., PCzPCA1) achieves higher hole injection ability than the compound (DECMA) taught by Liu.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 09/22/2011

By: Satoshi Seo  
Satoshi Seo